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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁴ : C07H 15/12, C12P 21/00, 19/34 C12N 15/00, 7/00, 1/20 C12Q 1/68, C07K 13/00	A1	(11) International Publication Number: WO 89/09777 (43) International Publication Date: 19 October 1989 (19.10.89)
(21) International Application Number: PCT/US89/01473 (22) International Filing Date: 7 April 1989 (07.04.89) (30) Priority data: 179,587 8 April 1988 (08.04.88) US 249,584 26 September 1988 (26.09.88) US (71) Applicant: ARCH DEVELOPMENT CORPORATION [US/US]; 1115-25 East 58th Street, Chicago, IL 60637 (US). (72) Inventor: SUKHATME, Vikas, P. ; 1511 East 56th Street, Chicago, IL 60637 (US). (74) Agent: MEINERT, M., C.; Marshall, O'Toole, Gerstein, Murray & Bicknell, Two First National Plaza, Ste. 2100, Chicago, IL 60603 (US).		(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: METHODS AND MATERIALS RELATING TO DNA BINDING PROTEINS (57) Abstract <p>DNA sequences associated with regulation of early stages of cell growth are described. Illustratively provided are human and mouse origin DNA sequence encoding early growth regulatory ("Egr") proteins which include "zinc finger" regions of the type involved in DNA binding. Immunological methods and materials for detection of Egr proteins and hybridization methods and materials for detection and quantification of Egr protein related nucleic acids are also disclosed.</p>		

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- 1 -

"METHODS AND MATERIALS RELATING TO
DNA BINDING PROTEINS"

5

CROSS-REFERENCE TO RELATED APPLICATIONS

10 This is a continuation-in-part application of
co-pending U.S. Patent Application Serial No. 179,587,
filed April 8, 1988.

15

BACKGROUND OF THE INVENTION

20 The present invention relates generally to DNA
binding regulatory proteins and more particularly to DNA
sequences encoding early growth regulatory proteins
25 possessing histidine-cysteine "zinc finger" DNA binding
domains, to the polypeptide products of recombinant
expression of these DNA sequences, to peptides and poly-
peptides whose sequences are based on amino acid
30 sequences deduced from these DNA sequences, to anti-
bodies specific for such proteins and peptides, and to
procedures for detection and quantification of such pro-
teins and nucleic acids related thereto.

35

 Among the most significant aspects of mam-
malian cell physiology yet to be elucidated is the
precise manner in which growth factors (e.g., hormones,
neurotransmitters and various developmental and
differentiation factors) operate to effect the regula-
tion of cell growth. The interaction of certain growth
factors with surface receptors of resting cells appears
to rapidly induce a cascade of biochemical events
thought to result in nuclear activation of specific
growth related genes, followed by ordered expression of
other genes. Analysis of sequential activation and
expression of genes during the transition from a resting
state ("G₀") to the initial growing state ("G₁") has
been the subject of substantial research. See, gener-

- 2 -

ally, Lau et al., Proc. Nat'l. Acad. Sci. (USA), 84,
1182-1186 (1987). Much of this research has involved
5 analysis of the expression of known genes encoding sus-
pected regulatory proteins (such as the proto-oncogenes,
c-fos and c-myc) following mitogen stimulation. An
10 alternative approach has involved attempts to identify
genes activated by mitogenic stimuli through differen-
tial screening of cDNA libraries prepared from resting
cells following exposure to serum and specific growth
15 factors. See, e.g., Lau et al., EMBO Journal, 4,
3145-3151 (1985). See also, Cochran et al., Cell, 33,
939-947 (1983), relating to the cloning of gene
20 sequences apparently regulated by platelet derived
growth factor.

Of interest to the background of the invention
25 is the continuously expanding body of knowledge regard-
ing structural components involved in the binding of
regulatory proteins to DNA. Illustratively, the so-
called receptor proteins are believed to bind to DNA by
30 means of zinc ion stabilized secondary structural
fingers premised on folding of continuous amino acid
sequences showing high degrees of conservation of
cysteines and histidines and hydrophobic residues. See,
35 e.g., Gehring, TIBS, 12, 399-402 (1987). For example, a
"zinc finger" domain or motif, present in Xenopus
transcription factor IIIA (TF IIIA), as well as the
Drosophila Kruppel gene product and various yeast
proteins, involves "repeats" of about 30 amino acid
residues wherein pairs of cysteine and histidine
residues are coordinated around a central zinc ion and
are thought to form finger-like structures which make
contact with DNA. The histidine-cysteine (or "CC-HH")
zinc finger motif, as opposed to a cysteine-cysteine
("CC-CC") motif of steroid receptors, is reducible to a
consensus sequence represented as C-X₂₋₄-C-X₃-F-X₅-L-X₂-
H-X₃-H wherein C represents cysteine, H represents

- 3 -

histidine, F represents phenylalanine, L represents leucine and X represents any amino acid. [See, Klug et al. TIBS, 12, 464-469 (1987); Blumberg et al., Nature, 328, 443-445 (1987); and Schuh et al., Cell, 47, 1025-1032 (1986).]

Of particular interest to the background of the invention is the recent report of Chowdhury et al., Cell, 48, 771-778 (1987), relating to an asserted "family" of genes encoding proteins having histidine-cysteine finger structures. These genes, designated "mkr1" and "mkr2", appear to be the first such isolated from mammalian tissue and are not correlated to any early growth regulatory events.

There continues to exist a need in the art for information concerning the primary structural conformation of early growth regulatory proteins, especially DNA binding proteins, such as might be provided by knowledge of human and other mammalian DNA sequences encoding the same. Availability of such DNA sequences would make possible the application of recombinant methods to the large scale production of the proteins in procaryotic and eukaryotic host cells, as well as DNA-DNA and DNA-RNA hybridization procedures for the detection, quantification and/or isolation of nucleic acids associated with these and related proteins. Possession of such DNA-binding proteins and/or knowledge of the amino acid sequences of the same would allow, in turn, the development of monoclonal and polyclonal antibodies thereto (including antibodies to protein fragments or synthetic peptides modeled thereon) for use in immunological methods for the detection and quantification of early growth regulatory proteins in fluid and tissue samples as well as for tissue specific delivery of substances such as labels and therapeutic agents to cells expressing the proteins. In addition, DNA probes based on the DNA sequences for these mammalian early growth

- 4 -

regulatory proteins may be of use in detecting gene
markers used for the diagnosis of those clinical
5 disorders which are linked to the marker genes.

BRIEF SUMMARY OF THE INVENTION

10

The present invention provides novel purified
and isolated DNA sequences encoding mammalian early
growth regulatory ("Egr") proteins which comprise one or
15 more histidine-cysteine zinc finger amino acid sequences
putatively providing DNA binding (and hence DNA replica-
tion or transcription regulatory) capacity. In
20 presently preferred forms, novel DNA sequences of the
invention comprise genomic and cDNA sequences encoding
human and mouse early growth regulatory proteins.
25 Alternate DNA forms, such as "manufactured" DNA,
prepared by partial or total chemical synthesis from
nucleotides, are also within the contemplation of the
invention.

30

Operative association of Egr-encoding DNA
sequences provided by the invention with homologous or
heterologous species expression control DNA sequences,
35 such as promoters, operators, regulators and the like,
allows for in vivo and in vitro transcription to form
messenger RNA which, in turn, is susceptible to transla-
tion to provide Egr proteins in large quantities. In
one presently preferred DNA expression system practiced
according to the invention, Egr-encoding DNA is opera-
tively associated with a bacteriophage T3 or T7 RNA
promoter DNA sequence allowing for in vitro transcrip-
tion and translation in a cell free system. Incor-
poration of novel DNA sequences of the invention into
procaryotic and eucaryotic host cells by standard trans-
formation and transfection processes involving suitable
viral and circular DNA plasmid vectors is also within
the contemplation of the invention and is expected to

- 5 -

provide useful proteins in quantities heretofore unavailable from natural sources. Illustratively, fragments of DNA encoding Egr protein of the invention have been incorporated in plasmid vectors resulting in expression by transformed E.coli hosts of fusion proteins sharing immunological characteristics of Egr protein. Use of mammalian host cells is expected to provide for such post-translational modifications (e.g., truncation, glycosylation, and tyrosine, serine or threonine phosphorylation) as may be needed to confer optimal biological activity on recombinant expression products of the invention.

Also provided by the present invention are novel, presumptively mitogen sensitive, DNA sequences involved in regulation of the transcription of Egr-encoding DNA, which sequences are expected to have utility in the efficient recombinant expression of Egr proteins as well as proteins encoded by other structural genes. In addition, the DNA sequences may be used as probes to detect the presence or absence of gene markers used for the diagnosis of clinical disorders linked to those gene markers.

Novel polypeptide products of the invention include polypeptides having the primary structural conformation (i.e., amino acid sequence) of Egr proteins or fragments thereof, as well as synthetic peptides, an analogs thereof, assembled to be partially or wholly duplicative of amino acid sequences extant in Egr proteins. Proteins, protein fragments, and synthetic peptides of the invention are expected to have therapeutic, diagnostic, and prognostic uses and also to provide the basis for preparation of monoclonal and polyclonal antibodies specifically immunoreactive with Egr proteins, as well as to provide the basis for the production of drugs for use as competitive inhibitors or potentiators of Egr. Preferred protein fragments and

- 6 -

synthetic peptides of the invention include those duplicating regions of Egr proteins which are not involved in DNA binding functions (i.e., regions other than the zinc fingers). Most preferred are peptides which share at least one continuous or discontinuous antigenic epitope with naturally occurring Egr proteins.

Antibodies of the invention preferably bind with high immunospecificity to Egr proteins, fragments, and peptides, preferably recognizing epitopes which are not common to other proteins, especially other DNA binding proteins.

Also provided by the present invention are novel procedures for the detection and/or quantification of Egr proteins and nucleic acids (e.g., DNA and mRNA) specifically associated therewith. Illustratively, antibodies of the invention may be employed in known immunological procedures for quantitative detection of Egr proteins in fluid and tissue samples. Similarly, DNA sequences of the invention (particularly those having limited homology to other DNAs encoding DNA binding proteins) may be suitably labelled and employed for the quantitative detection of mRNA encoding the proteins. Information concerning levels of Egr mRNA may provide valuable insights into growth characteristics of cells.

Among the multiple aspects of the present invention, therefore, is the provision of (a) novel purified and isolated Egr-encoding DNA sequences set out in Figures 1A, 3, and 4 as well as (b) Egr-encoding DNA sequences which hybridize thereto under hybridization conditions of the stringency equal to or greater than the conditions described herein and employed in the initial isolation of DNAs of the invention, and (c) synthetic or partially synthetic DNA sequences encoding the same, or allelic variant, or analog Egr polypeptides

- 7 -

which employ, at least in part, degenerate codons. Correspondingly provided are viral or circular plasmid DNA vectors incorporating such DNA sequences and pro-
5 caryotic and eucaryotic host cells transformed or trans-
fected with such DNA sequences and vectors as well as
10 novel methods for the recombinant production of Egr
proteins through cultured growth of such hosts and iso-
lation from the hosts or their culture media.

Preferred polypeptide products of the inven-
15 tion include those wholly or partially duplicating the
deduced sequence of the amino acid residues set out in
Figures 1A and 3 (i.e., mouse "Egr-1" and human
20 "EGR2"). Other preferred polypeptides include fusion
proteins such as cro-s-galactosidase/Egr-1 and bovine
growth hormone/Egr-1.

Presently preferred antibodies of the inven-
25 tion include those raised against synthetic peptides
partially duplicating deduced Egr amino acid sequences
of Figures 1A and 3 (e.g., the synthetic peptides H-L-R-
30 Q-K-D-K-K-A-D-K-S-C, the first 12 amino acid residues of
which duplicate mouse Egr-1 residues 416-427 with the
last cysteine added for coupling to KLH; and C-G-R-K-F-
35 A-R-S-D-E-R-K-R-H-T-K-I duplicating mouse Egr-1 residues
399-415). The antisera against the first peptide is
designated VPS10 and comprises a preferred antibody of
the invention.

As employed herein, the term "early growth
regulatory protein" shall mean and include a mammalian
DNA binding protein encoded by DNA whose transcription
temporally corresponds to cellular events attending the
G₀/G₁ growth phase transition. As employed herein,
"histidine-cysteine zinc finger amino acid sequence"
shall mean and include the following sequence of amino
acids C-X₂₋₄-C-X₃-F-X₅-L-X₂-H-X₃-H wherein C represents
cysteine, H represents histidine, F represents phenyl-
alanine, L represents lysine, and X represents an amino
acid.

- 8 -

Other aspects and advantages of the present invention will be apparent upon consideration of the following detailed description thereof which includes numerous illustrative examples of the practice of the invention, reference being made to the drawing wherein:

Figure 1A provides a 3086 base nucleotide sequence for a mouse Egr-1 DNA clone as well as a deduced sequence of 533 amino acid residues for the protein; Figure 1B provides a partial restriction map of Egr-1 DNA clones together with information concerning the position of the protein coding sequence and the locus of amino acids providing for histidine-cysteine zinc fingers;

Figure 2 provides an amino acid sequence alignment of the DNA binding domain of mouse Egr-1 in comparison with a zinc finger consensus sequence, with the Drosophila Kruppel sequence and with the "finger 2" sequence of Xenopus TFIIIA protein;

Figure 3 provides a 2820 base nucleotide sequence for a human EGR2 cDNA clone as well as a deduced sequence of 456 amino acids for the protein;

Figure 4 provides a 1200 base nucleotide sequence of a mouse Egr-1 genomic clone, specifically illustrating the 5' non-transcribed regulatory region thereof comprising bases -935 through +1; and

Figure 5 provides a restriction map and organization of the mouse Egr-1 genomic clone mgEgr-1.1 and a comparison to mouse Egr-1 cDNA.

DETAILED DESCRIPTION

The following examples illustrate practice of the invention. Example 1 relates to the preparation and structural analysis of cDNA for mouse Egr-1. Example 2 relates to confirmation of the presence of an Egr DNA sequence on human chromosome 5. Example 3 relates to the in vitro transcription and translation of mouse

- 9 -

Egr-1 cDNA. Example 4 relates to production of antibodies according to the invention. Example 5 relates to the isolation and characterization of genomic DNA which encodes mouse Egr-1. Example 6 relates to the isolation and characterization of cDNA encoding human EGR2. Example 7 relates to preparation, in an E. coli host, of a recombinant fusion protein including a portion of the deduced amino acid sequence of mouse Egr-1. Example 8 relates to use of DNA probes of the invention in the quantitative detection of EGR1 mRNA.

These examples are for illustrative purposes only and are not intended in any way to limit the scope of the invention.

EXAMPLE 1

Preparation and Structural Analysis of cDNA for Mouse Egr-1

Isolation of DNA encoding a mammalian early growth regulatory protein including one or more histidine-cysteine zinc finger amino acid sequences was performed substantially according to the procedures described in Sukhatme et al., Oncogene Research, 1, 343-355 (1987), the disclosures of which are specifically incorporated by reference herein.

Balb/c 3T3 cells (clone A31) from the American Type Culture Collection were grown to confluence in Dulbecco's Modified Eagle's medium (DME) supplemented with 10% fetal calf serum (FCS). The cells were rendered quiescent by reduction of the serum concentration to 0.75% for 48 hours. To induce the cells from quiescence into growth phase G₁, the medium was changed to 20% FCS with cycloheximide added to a final concentration of 10 µg/ml.

RNA was extracted from Balb/c 3T3 cells harvested three hours after induction of quiescent cells by

- 10 -

20% FCS and 10 µg/ml cycloheximide. A λgt10 cDNA library was constructed from this mRNA according to the procedures of Huynh et al., DNA Cloning, Vol. 1, 49-78 (Glover, D., ed., IRL Press, 1985). This library was screened differentially with single stranded cDNA prepared from quiescent cells and from cells exposed to serum and cycloheximide for 3 hours. These ³²P-labeled cDNA probes were prepared from poly A⁺ RNA as described in St. John, et al., Cell, 16, 443-452 (1979), except that 100 µCi of ³²P-dCTP (>3000 Ci/mmol), 0.02 mM cold dCTP and 2-5 µg of poly A⁺ RNA was used in each reaction. The mean size of the reverse transcribed probes, as assessed by alkaline agarose gel electrophoresis and subsequent autoradiography, was about 700 bases. Replica filter lifts (GeneScreenPlus, NEN-DuPont) were prepared essentially as described by Benton et al., Science, 196, 180-192 (1977), and approximately 3 x 10⁶ cpm of ³²P-cDNA were used per filter (90 mm diameter). Hybridizations were carried out at 65°C in 1% SDS, 10% dextran sulfate, and 1 M NaCl for a period of 16 hours. The filters were washed twice for twenty minutes each time, first at room temperature in 2 x SSC [Maniatis et al., Molecular Cloning, Cold Spring Harbor Laboratory (New York, 1982)], then at 65°C in 2 x SSC, 1% NaDodSO₄ and finally at 65°C in 0.2 x SSC. Autoradiograms were prepared by exposing the blots for 18 hours at -70°C with an intensifying screen.

A total of 10,000 cDNA clones from the Balb/c 3T3 λgt10 library were differentially screened. Seventy-eight clones were found to hybridize preferentially to single-stranded cDNA from fibroblasts stimulated for 3 hours with 20% FCS and cycloheximide as compared to single-stranded cDNA from quiescent cells. Inserts from these clones were cross-hybridized to each other, resulting in the sorting of forty clones into 7 cDNA families one of which was identified as c-fos.

- 11 -

Another cDNA clone, referred to as OC68, contained a 2.2 kb insert and was characterized further. This insert was subcloned into the Eco RI site of pUC13 and probes were generated for Northern blot analysis either from the insert or the corresponding pUC plasmid. Figure 1B illustrates a partial restriction digest map of the OC68 clone ("R" representing restriction sites for RsaI) along with that of a shorter clone, OC19t. Two RsaI digestion fragments, derived from the 5' end of clone OC68 and each comprising approximately 130 base pairs, were labeled and employed to re-screen the above-described λ gt10 cDNA library, resulting in the recovery of a 3.1 kb clone, designated OC3.1, shown in figure 1B. This clone was sequenced according to the method of Sanger et al., Proc. Nat'l. Acad. Sci. (USA), **74**, 5463 (1977). The 3086 base pair sequence obtained is set forth in Figure 1A along with the deduced sequence of 533 amino acid residues for the protein encoded, designated mouse "Egr-1".

The deduced amino acid sequence shows a single long open reading frame with a stop codon (TAA) at position 1858. The most 5', in-frame, ATG, at position 259, is flanked by sequences that fulfill the Kozak criterion

(^A_GNN(ATG)G) [Kozak, Nuc. Acids Res., **15**, 8125-8131 (1987)]. The sequence region upstream of this ATG is highly GC-rich and results in an absence of in-frame stop codons. The 3' untranslated region (UT) contains two "AT" rich regions (nucleotides 2550-2630 and 2930-2970). Similar sequences are found in the 3' UT regions of several lymphokine and proto-oncogene mRNAs, including granulocyte macrophage colony stimulating factor (GM-CSF), interleukin 1, interleukin 2, interleukin 3 (IL-3), α , β , and γ interferons, and c-fos, c-myc, and c-myb [Shaw et al., Cell, **46**, 659-667 (1986)]. These sequences may mediate selective mRNA degradation. The presence in the mouse Egr-1 transcript

- 12 -

of such regions is consistent with its short message half-life. Potential polyadenylation signals (AATAAA) are located at nucleotide positions 1865 and 3066, as well as at position 3053 (AATTAA) [Wickens et al., Science, 226, 1045-1051 (1984)].

The deduced amino acid sequence predicts a polypeptide of 533 amino acids with a molecular weight of 56,596. Based on structural considerations, namely a central region containing zinc fingers (described below), the Egr-1 protein can be divided into three domains. The N-terminal portion (amino acid residues 2 to 331) is rich in proline (14.2%) and serine (16%) residues with 7.9% alanines and 7.9% threonines. The C-terminal region (residues 417 to 533) also contains a very high proportion of prolines and serines (15.4 and 26.5%, respectively) and 10.3% alanines and 11.1% threonines. The large number of proline residues leads to a secondary structure that probably lacks α -helices. The central portion of the Egr-1 protein consists of three tandem repeat units of 28-30 amino acids, with the first unit starting at position 332. Each unit conforms almost exactly to the consensus sequence $TGX_3^YXCX_{2-4}CX_3FX_5LX_2HX_3H$ (see Figure 2), diagnostic of DNA binding zinc fingers [Berg, Science, 232, 485-486 (1986); Brown et al., Nature, 324, 215 (1986); and Brown et al., FEBS Letters, 186, 271-274 (1985)]. Furthermore, the Egr-1 fingers are connected by "H-C links" ($TGE_K^R P_Y^F X$) [Schuh et al., Cell, 47, 1025-1032 (1986)] found in the Xenopus TFIIIA gene (between fingers 1, 2, and 3), in the Drosophila Kruppel gap gene [Rosenberg et al., Nature, 319, 336-339 (1986)], and in genes from mouse and Xenopus that cross-hybridize to the Kruppel (Kr) finger domains: mkr1, mkr2 [Chowdhury et al., Cell, 48, 771-778 (1987)], and Xfin [Altaba et al., EMBO Journal, 6, 3065-3070 (1987)]. The sequence similarity amongst the Egr-1

- 13 -

fingers is 50-70%, whereas the sequence similarity between any of the Egr-1 fingers and those present in TFIIIA, Kruppel, mkrl, mkr2 or Xfin is 35-40%. Outside of the finger domains, it is noteworthy that the Egr-1 and Kr proteins each contain a very high proportion of Pro, Ala, and Ser residues [Schuh et al., Cell, 47, 1025-1032 (1986)]. However, there is no sequence similarity in these regions. Thus, Egr-1 and Kr are not homologous genes nor is Egr-1 related to mkrl, mkr2, Xfin, or TFIIIA. The Kr gene contains thirteen copies of the hexanucleotide (ACAAAA), or its complementary sequence, eight of which are located within 180 bp downstream from the Kr TATA box and five are in the 3' UT region. These sequences may serve as targets for other DNA binding proteins or in Kr gene autoregulation. The Egr-1 cDNA also contains nine copies of the ACAAAA sequence or its complement.

Following the work described above, Milbrandt [Science, 238, 797-799 (1987)], reported the isolation and sequence of a nerve growth factor (NGF) inducible cDNA (NGFI-A) from the rat pheochromocytoma PC12 line. A comparison of the deduced amino acid sequence of NGFI-A to that of mouse Egr-1 of Figure 1A reveals 98% sequence identity. Thus, mouse Egr-1 and rat NGFI-A are homologs. The putative initiation ATG chosen by Milbrandt corresponds to position 343 in the Figure 1A cDNA sequence, and is 84 nucleotides (28 amino acid residues) downstream of the ATG therein designated for translation initiation. Both ATG's have a purine at position -3 and a G at position +1 and the designation represented in Figure 1A of the more 5' ATG as the putative start codon is based on the experience of Kozak, Nuc. Acids Res., 15, 8125-8131 (1987), even though the more 3' ATG is surrounded by the longer Kozak consensus sequence (CCG/ACCATGG). Translation of an in vitro generated RNA transcript, described infra, selects the more 5' ATG for initiation.

- 14 -

It is noteworthy that a major difference in the deduced sequences of mouse Egr-1 and rat NGFI-A resides in the sequence spanning residues 61-68 of Egr-1 and 33-43 of NGFI-A. The former includes the sequence N-S-S-S-S-T-S-S while the latter includes the sequence N-N-S-S-S-S-S-S-S-S-S, accounting for the 3 residue difference in length of the putative polypeptides which is not accounted for by the difference in designation of the transcript initiation signal.

EXAMPLE 2

Human Chromosome Gene Mapping

To determine the human chromosomal localization of the gene corresponding to mouse Egr-1, the OC3.1 and OC19t cDNA clones were hybridized to a panel of rodent x human somatic cell hybrids. Southern blot analysis of the hybrid panel showed concordance between the presence of Egr-1 sequences and human chromosome 5. In situ hybridization to normal human metaphase chromosomes resulted in specific labeling only of chromosome 5, with the largest cluster of grains at 5q23-31. Specific labeling of these bands was also observed in hybridizations using an Egr-1 probe which does not contain finger sequences.

This localization is interesting in light of the non-random deletions [del(5q)] in human myeloid disorders (acute myelogenous leukemia) (AML), and myelodysplastic syndromes, that involve this chromosomal region. [Le Beau et al., Science, 231, 984-987 (1986); Dewald et al., Blood, 66, 189-197 (1985); and Van den Berghe et al., Cancer Genet. Cytogenet., 17, 189-255 (1985)]. Fifty percent of patients with therapy related AML show chromosome 5 abnormalities (interstitial deletions or monosomy) and cytogenetic analysis of the deletions has revealed that one segment, consisting of bands

- 15 -

5q23-31, is absent in the malignant cells of all patients who have aberrations of chromosome 5. These data suggest that loss of a critical DNA sequence leading to hemizyosity (or homozygosity) of a recessive allele may play an important role in the pathogenesis of these disorders, a mechanism substantiated for retinoblastoma. Although genes for a number of growth factors and receptors (IL-3, GM-CSF, β_2 -adrenergic receptor, endothelial cell growth factor, CSF-1, c-fms, pDGF receptor) are clustered in or near this region, Egr-1 (by virtue of its zinc fingers) is the only member of this group with potential transcriptional regulatory activity. It is therefore possible that its absence could lead to deregulated cell growth.

EXAMPLE 3

In Vitro Expression of Mouse Egr-1 cDNA

A 2.1 kb ApaI/ApaI fragment (comprising nucleotides 120-2224 of Figure 1A) was isolated from the OC3.1 DNA clone. This fragment includes the translation start (ATG) codon at nucleotide position 259 designated in Figure 1A. The fragment was blunt-ended with T4 DNA polymerase and cloned into the Bluescript vector KS M13(+) containing a T3/T7 bacteriophage promoter. The (T3) sense transcript was generated and in vitro translated in a standard rabbit reticulocyte lysate system (Promega Biotec, Madison, WI. 53711) including ^{35}S methionine as a radiolabel. An analogous in vitro transcription system was developed using a BglII/BglII fragment of OC3.1 (including nucleotides 301-1958 and not including the translation start designated in Figure 1A). The T7 sense transcript was employed in the translation system. Differential characterization of translation products by autoradiographic SDS PAGE indicated that the ATG at nucleotide position 259 is preferred as

- 16 -

a translation start codon when all potential start sites are present.

5

EXAMPLE 4

10 Preparation of Antibodies:

15 A first synthetic peptide based on the sequence of amino acid residues 416-427 of mouse Egr-1 was prepared and provided with a carboxy terminal cysteine residue. The peptide, H-L-R-Q-K-D-K-K-A-D-K-S-C, was coupled to KLH and employed to immunize New Zealand white rabbits. Animals were initially immunized 20 with 100 µg of the immunogen in Freund's Complete Adjuvant and every two weeks were boosted with 100 µg of immunogen with Freund's Incomplete Adjuvant. Sera, 25 designated VPS10, were isolated after 68 days and displayed an antibody titer of 1:12,800 based on reactivity with the antigen used to prepare the anti-sera.

30

A second synthetic peptide, based on residues 399 to 415 of mouse Egr-1, was prepared. The peptide, C-G-R-K-R-A-R-S-D-E-R-K-R-H-T-K-I, was coupled to KLH 35 and used to immunize rabbits as above, resulting in the production of antisera (designated VPS2) with a titer of 1:400.

EXAMPLE 5

Isolation of Genomic Mouse Egr-1 Clone and Characterization of Regulatory Regions

A mouse Balb/c 3T3 genomic library was prepared in a Stratagene (La Jolla, California) vector, λFIX, according to the manufacturer's instructions and probed using 1% SDS, 1 M NaCl, and 10% dextran sulfate at 65°C with stringent final wash in 0.2 x SSC at 65°C with a 2.1 kb ApaI/ApaI fragment and a 3.1 kb Eco RI/Eco

- 17 -

RI fragment derived from digestion of pUC13 including the mouse Egr-1 clone OC3.1. One positive clone, from approximately 300,000 screened, was designated mgEgr-1.1 and also hybridized to the extreme 5'-end 120 bp Eco RI-Apa I fragment from plasmid OC3.1.

A 2.4 kb Pvu-II-PvuII fragment and a 6.6 kb XbaI-XbaI fragment (see Figure 5) derived from the mgEgr-1.1 clone were subcloned into the SmaI and XbaI sites of pUC13 and pUC18 respectively, and the resulting plasmids (designated as p2.4 and p6.6) were used for restriction mapping analysis of transcription initiation sites and for nucleotide sequencing. Marked in Figure 4, and listed in Table 1, are possible regulatory elements identified in the 5' flanking sequence of mgEgr-1.1. A putative TATA motif (AAATA) is located 26 nucleotides upstream of the transcription start site. A "CCAAT" type sequence starts at nucleotide -337. Five different regions, each 10 nucleotides in length, located at -110, -342, -358, -374, and -412, are nearly identical to the inner core of the c-fos serum response element (Treisman, R., Cell, 46, 567 (1986)). Each has a 5-6 nucleotide AT rich stretch and is surrounded by the dinucleotide CC on the 5' side and GG on the other. Two potential TPA responsive elements (Lee, W., et al., Cell, 49, 741 (1987) and Angel, P., et al., Cell, 49, 729 (1987)) are located at nucleotides -610 and -867. Four consensus Spl (Briggs, M.R., et al., Science, 234, 47 (1986) binding sequences are at position -285, -649, -700 and -719. In addition, two sequences have been identified that might serve as cAMP response elements (Montimy, M.R., et al., Nature, 328, 175 (1987)) (-138 and -631).

- 18 -

TABLE 1

5 Location and Identification of Potential Regulatory Elements			
	<u>Element</u>	<u>Sequence</u> ¹	<u>Location</u> ²
10	TATA	AAATA	-26 to -22
	CCAAT	CCAAT	-337 to -333
Serum Response Element Consensus			
15	GATGTCCATATTAGGACATC	<u>TCCTTCCATATTAGGGCTTC</u>	-110 to -91
	CC TA AT GG	<u>GTGGCCC-AATATGGCCCTG</u>	-342 to -324
	G C	<u>CAGCGCCTTATATGGAGTGG</u>	-358 to -339
		<u>ACAGACCTTATTTGGGCAGC</u>	-374 to -355
		<u>AAACGCCATATAAGGAGCAG</u>	-412 to -393
20 TPA Responsive Element (AP1 binding site) Consensus			
25	C C	<u>CTGACTCG</u>	-610 to -603
	TGACT A	<u>CTGACTGG</u>	-867 to -860
30	G A		
	Spl binding site	GGGCGG	-285 to -280
35		GGGCGG	-649 to -644
		CCGCCC	-700 to -695
		GGGCGG	-719 to -714
	cAMP Response Element Consensus		
	TGACGTCA	<u>TCACGTCA</u>	-138 to -131
		<u>TGACGGCT</u>	-631 to -624

1. The underlined bases in the mouse Egr-1 gene sequence are those that do not match the consensus sequence.

2. The location numbers refer to the nucleotides of the mouse Egr-1 gene as indicated in Figure 4.

- 19 -

To obtain the genomic sequence and the intron-exon gene structure, specific oligonucleotides (17-mers at positions 83, 122, 174, 200, 379, 543, 611, 659, 905, 920, 1000, 1200, 1400, 1600, 1800, 2100, 2353, 2650, 2825) of the OC3.1 cDNA sequence (see Figure 1A) were used as primers for double stranded sequencing of plasmids p2.4 and p6.6. Comparison of the Egr-1 genomic sequence to the Egr-1 cDNA sequence showed the Egr-1 gene consists of 2 exons and a single 700 bp intron (between nucleotide position 556 and 557 as numbered in Figure 1A and as shown in Figure 5). Both the 5' and 3' splice junction sequences (not shown) are in excellent agreement with the consensus boundary sequences. Mount, S.M., Nucleic Acids Res., 10, 459 (1982).

25

EXAMPLE 6

30 Isolation and Characterization of Human EGR2 cDNA

A human genomic placental library in the vector EMBL3, prepared by Dr. C. Westbrook of the University of Chicago according to procedures described in Frischaufl et al., Jour. Mol. Biol., 170, 827-842 (1983), and a human leukocyte cosmid library prepared according to procedures described in Proc. Nat'l. Acad. Sci. (USA), 80, 5225-5229 (1983), were probed with the 2.1 kb ApaI fragment of OC3.1 (described in Example 5) using 1% SDS, 1 M NaCl and 10% dextrose sulfate at 50-55°C with a non-stringent final wash in 2 x SSC at 50-55°C. A single positive clone (designated HG6) was isolated from the first library and four clones (designated HG17, 18, 19 and 21, respectively) were isolated from the second library. A 6.6 kb SalI/EcoRI fragment of clone HG6 was found to hybridize with a 332 base pair HpaII/HpaII fragment of the mouse Egr-1 gene,

- 20 -

which letter fragment spans the putative zinc finger region. The 6.6 kb fragment, in turn, was employed to probe a cDNA library derived from human fibroblasts which have been stimulated for three hours with 20% fetal calf serum in the presence of 10 μ g/ml cyclohexamide. About 10,000 clones were screened and the fifty positive clones obtained (designated "zap-1 through zap-50") are being subjected to nucleotide sequence analysis. Preliminary sequence analysis reveals that three clones, zap-2, zap-8, and zap-32, all encode the same transcript, namely a protein designated human EGR2, shown in Figure 3. Preliminary analysis indicates approximately 92% homology between mouse Egr-1 and human EGR2 polypeptides in the zinc finger regions, but substantially less homology in the amino and carboxy terminal regions. Chromosome mapping studies, similar to those described in Example 2, indicate that human chromosome 10, at bands q21-22, constitutes a locus for the human EGR2 gene.

The plasmid zap-32, containing the full length human EGR2 clone, was used as a probe in Southern blot analysis on DNAs from 58 unrelated Caucasians. It was found that Hind III detects a simple two-allele polymorphism with bands at either 8.0 kb (A1) or 5.6 kb and 2.4 kb (A2). No constant bands were detected. The frequency of A1 was 0.90 and that of A2 was 0.10. No polymorphisms were detected for Apa I, BamH I, Ban II, Bgl I, Bgl II, BstE II, Dra I, EcoR I, EcoR V, Hinc II, Msp I, Pst I, Pvu II, Rsa I, Sac I, and Taq I in 10 unrelated individuals. Co-dominant segregation of the Hind III RFLP was observed in four large kindreds with a total of more than 350 individuals.

These data will be useful in gene linkage studies for mapping genes for certain genetic disorders. For example, the gene responsible for the dominantly inherited syndrome, multiple endocrine

- 21 -

neoplasia, type 2A (MEN-2A) has been assigned by linkage to chromosome 10. Simpson, et al., Nature, 328, 528 (1987). Studies are currently underway to determine the linkage relationship between MEN-2A and EGR2 and are expected to be useful in cloning the MEN-2A gene as well as in serving as a diagnostic marker for the disease.

EXAMPLE 7

Recombinant Expression Of Fusion Proteins

A 322 base HpaII/HpaII fragment (comprising nucleotides 1231-1553) derived from the OC3.1 cloned DNA was treated with DNA polymerase to fill in the single stranded ends. This fragment was inserted in plasmid pEX3 (obtained from K. Stanley, European Molecular Biology Laboratory, Postfach 10.2209, 6900 Heidelberg, F.R.G.) digested with SmaI. Stanley, K.K., et al., EMBO J., 3, 1429 (1984). This insertion placed the Egr-1 encoding DNA fragment in the same reading frame as plasmid DNA encoding cro- β -galactosidase, allowing for the expression of a fusion protein comprising the amino terminal residues of cro- β -galactosidase and 108 residues of Egr-1 amino acids 325 to 432. This cro- β -galactosidase/Egr-1 fusion plasmid, designated pFIG, was used to transform E. coli NF1.

Induced (42°C) and un-induced (30°C) cultured cell lysates from growth of the transformed NF1 cells were then analyzed by SDS-PAGE. Upon Coomassie stain analysis, only induced cell lysates included an approximately 108 kd product, indicating presence of the projected expression product. Western blot analysis, using the rabbit polyclonal anti-peptide antibody VPS10 (see Example 4) raised against H-L-R-Q-K-D-K-K-A-D-K-S-C, confirmed that the fusion protein product contained Egr sequences.

- 22 -

In a separate construction, a mouse Egr-1 insert, from plasmid OC3.1, was fused, in frame, to a plasmid containing sequences from bovine growth hormone according to the methods described in Slamon, D.J., et al., Science, 233, 347 (1986). The resultant plasmid, designated pV4, comprised a fusion protein containing a fusion gene coding for bovine growth hormone amino acids 1 to 192 and Egr-1 amino acids 2 to 533. This bGH/mouse Egr-1 DNA fusion plasmid, designated pV4, was expressed in E. coli and the resulting fusion protein, designated V4, was identified in Western blots by its reactivity with a bGH monoclonal antibody and its reactivity with VPS10 rabbit anti-Egr-1 peptide antiserum, prepared according to Example 4.

EXAMPLE 8

Determination of Egr Levels in Human Tumor and Non-Tumor Tissue

Using the mouse Egr-1 OC68 probe, Northern blot analyses were conducted to determine the levels of transcription of Egr protein encoding DNA in tumor versus surrounding normal tissue from resected human tumor specimens. The tumor samples were from lung (12), colon (7), colon mesastasis (1), bladder (1), rectal (1), giant cell (1), hepatoma (1), breast (1), MFH (malignant fibrous histiocytoma) (1), osteosarcoma (1) and rhabdomyosarcoma (1). In about 50% of these cases, there is markedly decreased (about three to ten-fold) expression of the Egr mRNA in tumor versus normal tissue. One implication of this finding is that Egr proteins of the invention may function as part of a negative regulatory pathway. In any event, it is clear that DNA sequences and antibodies of the invention are susceptible to use in differential diagnoses between tumorous and non-tumorous cell types.

- 23 -

It will be apparent from consideration of the foregoing illustrative examples that the present invention constitutes a substantial advance in the art and the achievement of a major goal in molecular biology, i.e., the characterization of genes which play a regulatory role in mammalian cell proliferation and differentiation. It will thus be understood that the information provided herein constitutes a basis for straightforward development of useful methods and materials not specifically the subject of the above examples. By way of illustration, possession of knowledge concerning the base sequence of cDNA and genomic DNA sequences encoding distinct mouse Egr-1 and human EGR2 early growth regulatory proteins comprising histidine-cysteine zinc finger amino acid sequences makes possible the isolation of other such structurally related proteins. The substantial homology between the zinc finger regions of Egr-1 and EGR2 coupled with lack of homology in other protein regions, when considered in light of the ability of Egr-1 probes to localize to human chromosome 5 while EGR2 probes localize to human chromosome 10, essentially assures the straightforward isolation of a human gene (provisionally designated "human EGR1") which encodes a protein more closely homologous to Egr-1 and a mouse gene (Egr-2) encoding a protein more closely homologous to EGR2.

While the above examples provide only limited illustration of in vitro and in vivo expression of DNA sequences of the invention, known recombinant techniques are readily applicable to development of a variety of procaryotic and eucaryotic expression systems for the large scale production of Egr proteins and even development of gene therapy regimens.

Knowledge of the specifically illustrated mouse Egr-1 and human EGR2 proteins of the invention has been demonstrated to provide a basis for preparation of

- 24 -

highly useful antibodies, also provides a wealth of
information concerning the nature of protein-nucleic
5 acid interactions which, in turn, constitutes a basis
for determination of significant early growth regulatory
events. For example, and by analogy to steroid receptor
10 protein structures, analysis of the structure of regions
flanking the zinc fingers of Egr-1 and EGR2 and related
proteins of the invention is expected to allow for
15 identification of substances which may interact with the
proteins to alter their DNA interactive capacities and
thus provide the basis for inhibition or augmentation of
their regulatory functions. Moreover, information
20 available concerning specific events of DNA interaction
of Egr proteins of the invention will permit, e.g.,
identification and use of potential competitive
25 inhibitors of these proteins.

Just as Egr encoding DNA of the invention is
conspicuously susceptible to use in differentiation of
human tumor and non-tumor cells, antibodies prepared
30 according to the invention are expected to be useful in
differential screening of cells based on relative
cellular concentrations of mRNA expression products and
35 in the determination of specific genes susceptible to
regulation by such products.

Because numerous modifications and variations
in the practice of the present invention are expected to
occur to those skilled in the art, only such limitations
as appear in the appended claims should be placed
thereon.

- 25 -

WHAT IS CLAIMED IS

5 1. A purified and isolated DNA sequence
encoding a mammalian early growth regulatory protein
which comprises one or more histidine-cysteine zinc
10 finger amino acid sequences.

15 2. The DNA sequence according to claim 1
encoding human EGR2 protein.

20 3. The DNA sequence according to claim 1
encoding mouse Egr-1 protein.

25 4. The DNA sequence according to claim 1
which is a cDNA sequence.

30 5. The DNA sequence according to claim 1
which is a genomic DNA sequence.

35 6. The DNA sequence according to claim 1
which is a wholly or partially synthetic DNA sequence.

 7. The DNA sequence according to claim 1
operatively associated with an homologous or
heterologous expression control DNA sequence.

 8. The DNA sequence according to claim 1
selected from the group consisting of the DNA sequences
set out in Figures 1A, 3, and 4.

 9. A procaryotic or eucaryotic host cell
transformed or transfected with a DNA sequence
comprising a DNA sequence according to claim 1 or 7.

 10. A viral or circular DNA plasmid vector
comprising a DNA sequence according to claim 1.

- 26 -

11. The viral or circular DNA plasmid vector
5 according to claim 10 further comprising an expression
control DNA sequence operatively associated with said
early growth regulatory protein encoding DNA.

10 12. A method for the production of an early
growth regulatory protein comprising:

15 growing, in culture, a host cell transformed
or transfected with a DNA sequence according to claim 1;
and

20 isolating from said host cell or culture the
polypeptide product of the expression of said DNA
sequence.

25 13. A method for the production of an early
growth regulatory protein comprising:

30 disposing a DNA sequence according to claim 1
in a cell free transcription and translation system; and
isolating from said system the polypeptide
product of the expression of said DNA sequence.

35 14. The polypeptide product of the in vitro
or in vivo expression of part or all of a protein encoding
region of a DNA sequence according to claim 1.

15. The polypeptide product according to
claim 14 which is a fusion protein comprising part or
all of a mammalian early growth regulatory protein which
comprises one or more histidine-cysteine zinc finger
amino acid sequences and part or all of a heterologous
proteins.

16. The polypeptide product according to
claim 15, which comprises a fusion of cro-g-
galactosidase and Egr-1 amino acid sequences or bovine
growth hormone and Egr-1 amino acid sequences.

- 27 -

5 17. A purified and isolated mammalian early growth regulatory protein comprising one or more histidine-cysteine zinc finger amino acid sequences.

10 18. The protein according to claim 17 and having the amino acid sequence set out in Figure 1A.

15 19. The protein according to claim 17 and having the amino acid sequence set out in Figure 3.

20 20. A synthetic peptide duplicative of a sequence of amino acids present in a mammalian early growth regulatory protein comprising one or more histidine-cysteine zinc finger amino acid sequences and
25 sharing at least one antigenic epitope of such protein.

30 21. The synthetic peptide of claim 20 and having an amino acid sequence partially duplicative of the amino acid sequence set out in Figure 1A.

35 22. The synthetic peptide of claim 20 and having an amino acid sequence partially duplicative of the amino acid sequence set out in Figure 3.

 23. The synthetic peptide of claim 20 and further characterized as duplicative of an amino acid sequence not involved in DNA binding functions.

 24. An antibody specifically immunoreactive with at least one epitope of a mammalian early growth regulatory protein comprising one or more histidine-cysteine zinc finger amino acid sequences.

- 28 -

25. The antibody according to claim 24
wherein said epitope is other than an epitope within the
5 DNA binding functional region thereof.

26. The antibody according to claim 24
10 selected from the group consisting of monoclonal and
polyclonal antibodies.

27. The antibody according to claim 24
15 capable of specifically binding with a proteinaceous
material comprising an amino acid sequence duplicating
an antigenic epitope within the following amino acid
20 sequence:

H-L-R-Q-K-D-K-K-A-D-K-S-C.

28. The antibody according to claim 24
25 capable of specifically binding with a proteinaceous
material comprising an amino acid sequence duplicating
an antigenic epitope within the following amino acid
30 sequence:

C-G-R-K-F-A-R-S-D-E-R-K-R-H-T-K-I.

29. A method for quantitative detection of a
35 mammalian early growth regulatory protein comprising one
or more histidine-cysteine zinc finger amino acid
sequences based on the immunological reaction of the
same with an antibody according to claim 24.

30. A method for quantitative detection
within a sample of messenger RNA transcripts for
mammalian early growth regulatory proteins comprising
one or more histidine-cysteine zinc finger amino acid
sequences comprising the step of hybridizing RNA within
said sample with a DNA sequence partially or wholly
duplicating a DNA sequence according to claim 1.

- 29 -

31. A method for quantitative detection
within a sample of DNA encoding for mammalian early
5 growth regulatory proteins comprising one or more
histidine-cysteine zinc finger amino acid sequences
comprising the step of hybridizing DNA within said
10 sample with a DNA sequence partially or wholly
duplicating a DNA sequence according to claim 1.

32. A method for detecting a disease
15 genetically linked to a mammalian Egr gene comprising
the step of quantitating mammalian early growth
regulatory DNA sequences according to claim 1.

20

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1/21

10 20 30 40 50 60
GGGAGCCGCGCGGATTGCGCGCGCGCGCAGCTTCCGCGCGCAAGATCGGCCCC

70 80 90 100 110 120
TGCCCCAGCCTCCGCGCAGCCCTGCGTCCACCGCGCGGCTACCGCCAGCCTGGG

130 140 150 160 170 180
GGCCCCACTACACTCCCCGAGTGTCGCCCTGCACCCCGCATGTAAACCGGCAACCCCC

190 200 210 220 230 240
GGCGAGTGTGCCCTCAGTAGCTTCGGCCCCCGGGCTGGCCCCACCAATCAGTTCT

250 260 270 280 290 300
CCAGCTCGTGGTCCGGGATGGCAGCGGCCCAAGCGCGAGATGCAATTGATGTCTCCGCTG
MetAlaAlaAlaLysAlaGluMetGlnLeuMetSerProLeu

310 320 330 340 350 360
CAGATCTGACCCGTTCCGGCTCCTTTCCCTCACTCACCCACCATGGACAACACCCCAA
GlnIleSerAspProPheGlySerPheProHisSerProThrMetAspAsnTyrProLys

370 380 390 400 410 420
CTGGAGGAGATGCTGTGAGCAACGGGGCTCCCCAGTTCTCGGTGCTGCCGAACC
LeuGluGluMetMetLeuLeuSerAsnGlyAlaProGlnPheLeuGlyAlaAlaGlyThr

FIGURE 1.1

SUBSTITUTE SHEET

2/21

430	440	450	460	470	480
CCAGAGGCGCGGTAATAGCAGCAGCAGCAGCAGCGGGGGCGGTGGTGGGGC					
ProGlySerGlyGlyAsnSerSerSerThrSerSerGlyGlyGlyGlyGly					
490	500	510	520	530	540
GGCAGCAACAGGCGCAGCGCCTTCAATCCTCAAGGGAGCGGAGCAACACCTAT					
GlySerAsnSerGlySerSerAlaPheAsnProGlnGlyGluProSerGluGlnProTyr					
550	560	570	580	590	600
GAGCACCTGACCACAGAGTCCTTTCTGACATCGCTCTGAATAATGAGAGCGGATGGTG					
GluHisLeuThrThrGluSerPheSerAspIleAlaLeuAsnGluLysAlaMetVal					
610	620	630	640	650	660
GAGACGAGTTATCCCGAGCCAAACGACTCGGTGGCTCCCATCACCTATACTGGCCGCTTC					
GluThrSerTyrProSerGlnThrThrArgLeuProProIleThrTyrThrGlyArgPhe					
670	680	690	700	710	720
TCCCTGGAGCCCGCACCCAAACAGTGGCAACACTTTGTGGCCTGAACCCCTTTTCAGCCTA					
SerLeuGluProAlaProAsnSerGlyAsnThrLeuTrpProGluProLeuPheSerLeu					
730	740	750	760	770	780
GTCAGTGGCCTCGTGAGCATGACCAATCCTCCGACCTCTTCATCCTCGGCGCCTTCTCCA					
ValSerGlyLeuValSerMetThrAsnProProThrSerSerSerAlaProSerPro					
790	800	810	820	830	840
GCTGCTTCATCGTCTTCCCTCGCTCCAGAGCCCGCCCTGAGCTGTGCCGTGCCGTCC					
AlaAlaSerSerSerSerAlaSerGlnSerProProLeuSerCysAlaValProSer					

FIGURE 1.2

SUBSTITUTE SHEET

3/21

850	860	870	880	890	900
AACGACAGTCCCATCTACTCGGCTGGCCACCTTTCCTACTCCCAACACTGACATT					
AsnAspSerSerProIleTyrSerAlaAlaProThrPheProThrProAsnThrAspIle					
910	920	930	940	950	960
TTTTCCTGAGCCCAAGCCAGGCCCTTTCCTGGCTCGGCAGGCACAGCCTTGCCAGTACCCG					
PheProGluProGlnSerGlnAlaPheProGlySerAlaGlyThrAlaLeuGlnTyrPro					
970	980	990	1000	1010	1020
CCTCCTGCCTACCTGCCACCAAGGTGGTTCCAGGTTCCCATGATCCCTGACTATCTG					
ProProAlaTyrProAlaThrLysGlyGlyPheGlnValProMetIleProAspTyrLeu					
1030	1040	1050	1060	1070	1080
TTTCCACAACAACAGGGAGACCTGAGCCTGGGCACCCAGACCAAGAGCCCTTCCAGGGT					
PheProGlnGlnGlyAspLeuSerLeuGlyThrProAspGlnLysPropheGlnGly					
1090	1100	1110	1120	1130	1140
CTGGAGAACCGTACCCAGCAGCCTTCGCTCACTCCACTATCCACTATTAAAGCCTTCGCC					
LeuGluAsnArgThrGlnGlnProSerLeuThrProLeuSerThrIleLysAlaPheAla					
1150	1160	1170	1180	1190	1200
ACTCAGTCGGGCTCCAGGACTTAAAGGCTCTTAATACCACCTACCAATCCAGCTCATC					
ThrGlnSerGlySerGlnAspLeuLysAlaLeuAsnThrThrTyrGlnSerGlnLeuIle					
1210	1220	1230	1240	1250	1260
AAACCCAGCCGATGCGCAAGTACCCCAACCGGCCAGCAAGACACCCCCCATGAACGC					
LysProSerArgMetArgLysTyrProAsnArgProSerLysThrProProHisGluArg					

FIGURE 1.3

SUBSTITUTE SHEET

4/21

1270	1280	1290	1300	1310	1320
CCATATGCTTGCCCTGTCGAGTCCTGCGATCGCCGCTTTTCTCGCTCGGATGAGCTTACC					
ProTyrAlaCysProValGluSerCysAspArgArgPheSerArgSerAspGluLeuThr					
1330	1340	1350	1360	1370	1380
CGCCATATCCGCATCCACACAGGCCAGAGCCCTTCCAGTGTGGAATCTGCATGCGTAAC					
ArgHisIleArgIleHisThrGlyGlnLysProPheGlnCysArgIleCysMetArgAsn					
1390	1400	1410	1420	1430	1440
TTCAGTCGTAGTACCACCTTACCACCCACATCCGCCACCCACACAGCGGAGAGCCTTTT					
PheSerArgSerAspHisLeuThrThrHisIleArgThrHisThrGlyGluLysProPhe					
1450	1460	1470	1480	1490	1500
GCCTGTGACATTTGTGGAGGAAGTTTGCCAGGAGTGATGAACGCAAGAGGCATACCAA					
AlaCysAspIleCysGlyArgLysPheAlaArgSerAspGluArgLysArgHisThrLys					
1510	1520	1530	1540	1550	1560
ATCCATTTAAGACAGAGGACAAAGACAGACAAAGTGTTGGTGGCCTCCCCGGCTGCC					
IleHisLeuArgGlnLysAspLysLysAlaAspLysSerValValAlaSerProAlaAla					
1570	1580	1590	1600	1610	1620
TCTTCACTCTCTTCTTACCCATCCCGAGTGGCTACCTCCTACCCATCCCCCTGCCACC					
SerSerLeuSerSerTyrProSerProValAlaThrSerTyrProSerProAlaThrThr					
1630	1640	1650	1660	1670	1680
TCATTCCCATCCCCCTGTGCCCACTTCCTACTCCTCCTGGCTCCTCCACCTACCCATCT					
SerPheProSerProValProThrSerTyrSerSerProGlySerSerThrTyrProSer					

FIGURE 1.4

SUBSTITUTE SHEET

5/21

1690	1700	1710	1720	1730	1740
CCTGCGCACAGTGGCTTCCCGTCGCGTCAGTGGCCACCACCTTTGCCCTCCGTTCCACCT					
ProAlaHisSerGlyPheProSerProSerValAlaThrThrPheAlaSerValProPro					
1750	1760	1770	1780	1790	1800
GCTTTCCCCACCCAGGTCAGCAGCTTCCCGTCTGCGGCGTCAGCAGCTCCTTCAGCACC					
AlaPheProThrGlnValSerSerPheProSerAlaGlyValSerSerPheSerThr					
1810	1820	1830	1840	1850	1860
TCAACTGGTCTTTCAGACATGACAGCGACCTTTTCTCCAGGACAATTGAAATTGCTAA					
SerThrGlyLeuSerAspMetThrAlaThrPheSerProArgThrIleGluIleCys					
1870	1880	1890	1900	1910	1920
AGGGAAATAAAGAAAGCAAGGGAGAGGCAGGAAGACATAAAGCACAGGAGGGAAGAG					
1930	1940	1950	1960	1970	1980
ATGGCCGCAAGAGGGGCCACCTCTTAGGTCAGATGGAAGATCTCAGAGCCAAGTCCCTTCT					
1990	2000	2010	2020	2030	2040
ACTCACGAGTAGAAGGACCGTTGGCCCAACAGCCCTTTTCACTTACCATCCCTGCCCTCCCCC					
2050	2060	2070	2080	2090	2100
GTCCTGTTCCCTTTGACTTCAGCTGCCCTGAACAGCCATGTCCAAGTTCTTCACTCTAT					

FIGURE 1.5

2110 2120 2130 2140 2150 2160
CCAAAGGACTTGATTGTCATGGTATTGGATAAATCATTTTCAGTATCCTCTCCATCACATG

2170 2180 2190 2200 2210 2220
CCTGGCCCTTGCTCCCTTCAGCGCTAGACCATCAAGTTGGCATAAAGAAAAAATGGG

2230 2240 2250 2260 2270 2280
TTTGGGCCCCCAGAACCCCTGCCCTGCATCTTTGTACAGCATCTGTGCCATGGATTTTGT

2290 2300 2310 2320 2330 2340
TTCCTTGGGGTATTCTTGATGTGAAGATAATTGCACTACTCTATTGTATTATTGGAGTT

2350 2360 2370 2380 2390 2400
AAATCCTCACTTTGGGGAGGGGGAGCAAGCCAAACCAATGATGATCCTCTATT

2410 2420 2430 2440 2450 2460
TTGTGATGACTCTGCTGTGACATTAGGTTTGAAGCATTTTTTTTTTCAAGCAGCAGTCCT

2470 2480 2490 2500 2510 2520
AGGTATTAACTGGAGCATGTGTCAGAGTGTGTCCGTTAATTTTGTAAATACTGGCTCG

FIGURE 1.6

SUBSTITUTE SHEET

7/21

2530 2540 2550 2560 2570 2580
ACTGTAACCTCACAATGTGACAAAGTATGGTTTGGTTGGGTTTGTGTTTGGAGAAT

2590 2600 2610 2620 2630 2640
TTTTTTGCCCCGTCCTTTGGTTTCAAAAGTTTCACGCTCTGGTGCCCTTTGTGTGACACG

2650 2660 2670 2680 2690 2700
CCTTCCGATGGCTTGACATGCGCAGATGTGAGGGACACGCTCACCTTAGCCCTTAAGGGG
2710 2720 2730 2740 2750 2760
TAGGAGTGATGTGTGGGGGAGGCTTGAGAGCAAAACGAGGAAGAGGGCTGAGCTGAGC

2770 2780 2790 2800 2810 2820
TTTCGGTCTCCAGATGTAAAGAAAGAAATTTAAACAAATACTGAACCTCAAAAAGTC

FIGURE 1.7

SUBSTITUTE SHEET

8/21

2830 2840 2850 2860 2870 2880
TATTTTCTAAACTGAAATGTAAATTATACATCTATTCAGGAGTTGGAGTGTGTGGT

2890 2900 2910 2920 2930 2940
TACCTACTGAGTAGGCTGCAGTTTTTGTATGTTATGAACATGAAGTTCATTATTTGTGG

2950 2960 2970 2980 2990 3000
TTTTTATTACTTTGTACTTGTGTTTGCTTAAACAAAGTAACCTGTTTGGCTTATAACA

3010 3020 3030 3040 3050 3060
CATTGAATGCGCTCTATTGCCCCATGGGATATGTGGTGTGTATCCTTCAGAAAAATTAAAA

3070 3080
GGAAAAATAAAAAAATAAAAAA

FIGURE 1.8

SUBSTITUTE SHEET

9/21

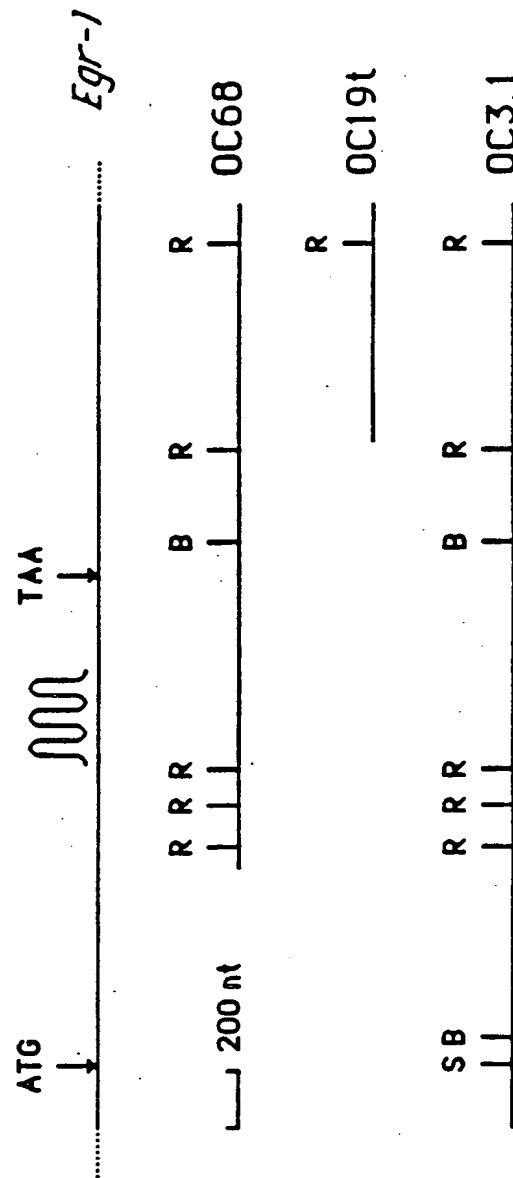


FIGURE 1B

consensus sequence

FRY
R
TGEK

[illegible]

Murine Egr-1

Drosophila Kruppel

**Xenopus TFIIA
(finger 2)**

FIGURE 2

11/21

10	20	30	40	50	60
TTTTTTT	TGGTG	TGTTGGT	GTTTAAAGT	GTGGGCAAA	AGGATACCA
70	80	90	100	110	120
TCCAGGCTCAGTCCAACCCTCTCCA	AACNGTGTCTTTCTGACACTCCAGGTAGCGA				
130	140	150	160	170	180
GGGAGTTGGGTCTCCAGGTTGTGCGAGGAGCAAATGATGACCGCCCAAGGCCGTAGACA	AAA				
					MetMetThrAlaLysAlaValAspLys
190	200	210	220	230	240
ATCCCAGTAAC	TCTCAGTGGTTTGTGCACCCAGCTGTCTGACAA	CATCTACCCGGTGGAG			
IleProValThrLeuSerGlyPheValHisGlnLeuSerAspAsnIleTyrProValGlu					
250	260	270	280	290	300
GACCTCGCCGCCACGTCGGTGACCATCTTTCCCAATGCCGA	ACTGGGAGGCCCTTTGAC				
AspLeuAlaAlaThrSerValThrIlePheProAsnAlaGluLeuGlyGlyPropheAsp					
310	320	330	340	350	360
CAGATGAACGGAGTGGCCGAGATGGCATGATCAACATTGACATGACTGGAGAGAAGAGG					
GlnMetAsnGlyValAlaGlyAspGlyMetIleAsnIleAspMetThrGlyGluLysArg					

FIGURE 3.1

SUBSTITUTE SHEET

12/21

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370      380      390      400      410      420
TCGTTGGATCTCCCATATCCACAGAGCTTTGGTCCCGTCTCTGCACCTAGAAACAGACC
SerLeuAspLeuProTyrProSerSerPheAlaProValSerAlaProArgAsnGlnThr

430      440      450      460      470      480
TTCACCTTACATGGGCAAGTTCTCCATTGACCCACAGTACCTGGTGCCAGCTGCTACCCA
PheThrTyrMetGlyLysPheSerIleAspProGlnTyrProGlyAlaSerCysTyrPro

490      500      510      520      530      540
GAAGGCATAATCAATATTGTGAGTGCAGGCATCTTGCAAGGGTCACTTCCCCAGCTTCA
GluGlyIleIleAsnIleValSerAlaGlyIleLeuGlnGlyValThrSerProAlaSer

550      560      570      580      590      600
ACCACAGCCTCATCCAGCGTCACCTCTGCCTCCCCAACCCACTGGCCACAGGACCCCTG
ThrThrAlaSerSerSerValThrSerAlaSerProAsnProLeuAlaThrGlyProLeu

610      620      630      640      650      660
GGTGTGTGCACCATGTCCCAGACCCAGCCTGACCTGGACCACCTGTACTCTCCGCCACCCG
GlyValCysThrMetSerGlnThrGlnProAspLeuAspHisLeuTyrSerProProPro

670      680      690      700      710      720
CCTCCTCCTCCTTATTCTGGCTGTGCAGGAGACCTCTACCAGGACCCCTTCTGCGTTCCTG
ProProProTyrSerGlyCysAlaGlyAspLeuTyrGlnAspProSerAlaPheLeu

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FIGURE 3.2

SUBSTITUTE SHEET

13/21

730	740	750	760	770	780
TCAGCAGCCACCTCCACCTCTTCCTCTCTGGCCTACCCACCCACCTCCTTCCTATCCA					
SerAlaAlaThrThrSerThrSerSerSerLeuAlaTyrProProProSerTyrPro					
790	800	810	820	830	840
TCCCCAAGCCAGCCAGGACCCAGGTCTCTTCCCAATGATCCAGACTATCCTGGATTC					
SerProLysProAlaThrAspProGlyLeuPheProMetIleProAspTyrProGlyPhe					
850	860	870	880	890	900
TTTCCATCTCAGTGCCAGAGACCTACATGTACAGCTGGCCCGACCCGTAAGCCCTTT					
PheProSerGlnCysGlnArgAspLeuHisGlyThrAlaGlyProAspArgLysProPhe					
910	920	930	940	950	960
CCCTGCCCACTGGACACCCCTGCGGGTGCCCCCTCCACTCACTCTCTACAATCCCGT					
ProCysProLeuAspThrLeuArgValProProProLeuThrProLeuSerThrIleArg					
970	980	990	1000	1010	1020
AACTTTACCCCTGGGGGCCCCAGTGCTGGGATGACCGGACCGAGGGCCAGTGGAGGCAGC					
AsnPheThrLeuGlyGlyProSerAlaGlyMetThrGlyProGlyAlaSerGlyGlySer					
1030	1040	1050	1060	1070	1080
GAGGACCCCGCTGCCCTGGTAGCAGCTCAGCAGCAGCAGCGCCGCCGCCGCCGCC					
GlutProArgLeuProGlySerSerAlaAlaAlaAlaAlaAlaAlaAlaAlaAla					

FIGURE 3.3

SUBSTITUTE SHEET

14/21

1090	1100	1110	1120	1130	1140
TATAACCCACACCTGCCACTGCGGCCCATTTCTGAGGCCCTCGCAAGTACCCCAACAGA					
TyrAsnProHisLeuProLeuArgProIleLeuArgProArgLysTyrProAsnArg					
1150	1160	1170	1180	1190	1200
CCCAGCAAGACGCGGTGCACGAGAGGCCCTACCCGTGCCAGCAGAAGGCTGCGACCCGG					
ProSerLysThrProValHisGluArgProTyrProCysProAlaGluGlyCysAspArg					
1210	1220	1230	1240	1250	1260
CGGTTCCTCCGCTCTGACGAGCTGACACGGCACATCCGAATCCACACTGGGCATAAGCCC					
ArgPheSerArgSerAspGluLeuThrArgHisIleArgIleHisThrGlyHisLysPro					
1270	1280	1290	1300	1310	1320
TTCCAGTGTCCGATCTGCATGCGCAACTTCAGCCGCAGTGACCACTCACCACCCATATC					
PheGlnCysArgIleCysMetArgAsnPheSerArgSerAspHisLeuThrThrHisIle					
1330	1340	1350	1360	1370	1380
CGCACCCACACCGGTGAGAAGCCCTTCGCCCTGTGACTACTGTGGCCGAAAGTTTGCCCGG					
ArgThrHisThrGlyGluLysPropheAlaCysAspTyrCysGlyArgLysPheAlaArg					
1390	1400	1410	1420	1430	1440
AGTGATGAGAGGAAGCGCCACACCAAGATCCACCTGAGACAGAAAGAGCGGAAAGCAGT					
SerAspGluArgLysArgHisThrLysIleHisLeuArgGlnLysGluArgLysSerSer					

FIGURE 3.4

SUBSTITUTE SHEET

15/21

1450 1460 1470 1480 1490 1500
GCCCCCTCTGCATCGGTGCCAGCCCCCTCTACAGCCTCCTGCTCTGGGGCGTGACAGGCC
AlaProSerAlaSerValProAlaProSerThrAlaSerCysSerGlyGlyValGlnAla

1510 1520 1530 1540 1550 1560
TGGGGGTACCCCTGTGCAGCAGTAACAGCAGCAGTCTTGGCGGAGGGCGCTCGCCCCCTTG
TrpGlyTyrProValGlnGlnEnd

1570 1580 1590 1600 1610 1620
CTCCTCTCGGACCCGGACACCTTGAGATGAGACTCAGGCTGATACACCAGCTCCCAAAGG

1630 1640 1650 1660 1670 1680
TCCCGGAGGCCCTTTGTCCACTGGAGCTGCACAACAACACTACCACCTTTCCCTGTCCC

1690 1700 1710 1720 1730 1740
TCTCTCCCTTTGTGGGCAAGGGCTTTGGTGGAGCTAGCACTGCCCCCTTTCCACCTAG

1750 1760 1770 1780 1790 1800
AAGCAGGTTCTTCCTAAACTTAGCCCATTTCTAGTCTCTCTTAGGTGAGTTGACTATCAA

FIGURE 3.5

SUBSTITUTE SHEET

16/21

1810 1820 1830 1840 1850 1860
CCCAAGGCAAAGGGAGGCTCAGAAAGGAGGTGGTGGGATCCCCTGGCCAAGAGGGCT

1870 1880 1890 1900 1910 1920
GAGGTCTGACCCCTGCTTTAAAGGGTTGTTGACTAGGTTTGTCTACCCCACTTCCCCCTTA

1930 1940 1950 1960 1970 1980
TTTTGACCCATCACAGGTTTTTTGACCCCTGGATGTCAGAGTTGATCTAAGACGTTTTCTAC

1990 2000 2010 2020 2030 2040
AATAGGTTGGGAGATGCTGATCCCTTCAAGTGGGGACAGCAAAGCAAGCAAACCTGA

2050 2060 2070 2080 2090 2100
TGTGCACTTTATGGCTTGGGACTGATTTGGGGGACATTGTACAGTGAGTGAAGTATAGCC

2110 2120 2130 2140 2150 2160
TTTATGCCACACTCTGTGGCCCTAAATGGTGAATCAGAGCATATCTAGTTGTCTCAACC

FIGURE 3.6

17/21

2170 2180 2190 2200 2210 2220
CTTGAAGCAATATGTATTATATACTCAGAGAACAGAAAGTGCAATGTGATGGGAGGAACGT

2230 2240 2250 2260 2270 2280
AGCAATATCTGCTCCCTTTTCGAGTTGTTGAGAAATGTAGGCTATTTTTCAGTGTATAT

2290 2300 2310 2320 2330 2340
CCACTCAGATTTTGTGTATTTTGTGATGTACCCACACTGTTCTCTAAATTCCTGAATCTTTG

2350 2360 2370 2380 2390 2400
GGAAAAATGTAAAGCATTTATGATCTCAGAGGTTAACTTATTTAAGGGGATGTACATA

2410 2420 2430 2440 2450 2460
TTCTCTGAACCTAGGATGCATGCCAATTGTGTGGAGTGTCCTTGGTCGCCCTGTGTGAT

2470 2480 2490 2500 2510 2520
GTAGACAAATGTTACAAGGCTGCATGTAAATGGGTTGCCCTTATTATGGAGAAAAAATCA

FIGURE 3.7

18/21

2530 2540 2550 2560 2570 2580
CTCCCTGAGTTTAGTATGGCTGTATATTATGCCTATTAATTTCAAAATTTTTTTAG
2590 2600 2610 2620 2630 2640
AGTATATTTTGTATGCTTTTGTGTTTGTGACTTAAAGTGTTACCTTTGTAGTCAAATTC
2650 2660 2670 2680 2690 2700
AGATAAGAAATGTACATAATGTTACCGGAGCTGANNNTTGTGGTCATTAGCTCTTAATA
2710 2720 2730 2740 2750 2760
GTTGTGAAAAATAAATCTATTCTAACGCAAAACCACCTGAAGTTCAGATATAATGG
2770 2780 2790 2800 2810
ATGGTTTGTGACTATAGTGTAATAAATACTTTTCAACAAAAAATAAAAAA

FIGURE 3.8

19/21

-935
ACGAGAGGAA TAGCCTTTCB ATTCTGGBTB GTGCATTGGA AGCCCCAGGC TCTANNACCC -876

-875
CCAACCTACT GACTGTTGGC CGAGTATGCA CCGGACTGCT AGCTABGCAG TGTCCCAAGA -816

-815
ACCACTAGCC AAATGTCCTG GCCTCAGTTT TCCGGBTGAC ACCTGGAAAG TGACCCCTGCC -756

-755
ATTAGTAGAB GCTCAGGTCA GGGCCCCGCC TCTCTGCGC GGCCTCTGCC CTAGCCCCGCC -696

-695
CTGCCBCTCC TCCCTCCTCC AGGCTCCTC CCACGCTCCC CBABBTBBBC BBBTBAGCCC -636

-635
AGGATGACBB CTGTABAACC CCGGCTTGAC TCGCCCTGBC CCCCAGGCCB BGCCTGGCT -576

-575
TCCCTAGCCC AGCTCGCACC CBBGGGCCBT CBBAGCCGCC BCBCGCCCBG CTCTACGCC -516

-515
CTGGCCCTCC CCACGCCGCC GTCCCCGACT CCCCAGCCCB CTCAGBCTCC CAGTTGGBAA -456

-455
CCAAGGAGBB BGAGGATGGB GGGGGGGGTG TGCBCCGACC CBBAAACGCC ATATAAGGAG -396

-395
CAGGAAGGAT CCCCCGCCCB AACAGACCTT ATTGGBGCB CBCCTTATAT GGAGTGGCTC -336

FIGURE 4.1

SUBSTITUTE SHEET

FIGURE 4.2

-335	<u>AAATATGCCCC</u> TGCCGCTTCC GGCCTCTGGGA GGAAGGGGCGA GCGGGGGTTG <u>GGGCGGGGGCG</u>	-276
-275	AAAGCTGGGAA CTCCAGGCGC CTGGCCCGGG AGGCCACTGC TGCTGTTCCA ATACTAGGCT	-216
-215	TTCCAGGAGC CTGAGCGCT GCGATGCCGG AGCGGGTGGC AGGGTGGAGG TGCCCAACACAC	-156
-155	<u>TCCTGGATGG</u> GAGGGCTTCA <u>CGTCACTCCG</u> GGTCCTCCCC GCGGGTCCCT <u>CCATATTAGG</u>	-96
-95	GGTTCCTGCT TCCCATATAT GGCCATGTAC GTACAGGCGG AGGCGGGGCC GTGCTGTTCC	-36
-35	AGAGCCCTTGA <u>ATA</u> TAGGCC GATTCGGGGA GTGCGGAGAG ATCCGAGCGC GCAGAACTTG	+25
+26	GGGAGCGCGCC GCGGCGGATC GCGCGCGCGG CCGGCTTCCG CGGCGCGCAG ATCGGGCCCT	+85
+86	GGCCCAAGCT CGCGGGCAGC CCTGCGTCCA CCACGGGGCG CGGCTACCGC CAGGCTGGGG	+145
+146	GGCCAGCTAC ACTCCCGGCA GTGTGCCCC GTACCCCGCA TGTACCGCGG CGAACCGCGG	+205
+206	GCGAGTGTG CCTCAGTAGC TTGCGGCGCG GGTGCGGCC ACCAGCCCAAC ATCAGTTCTC	+265

SUBSTITUTE SHEET

21/21

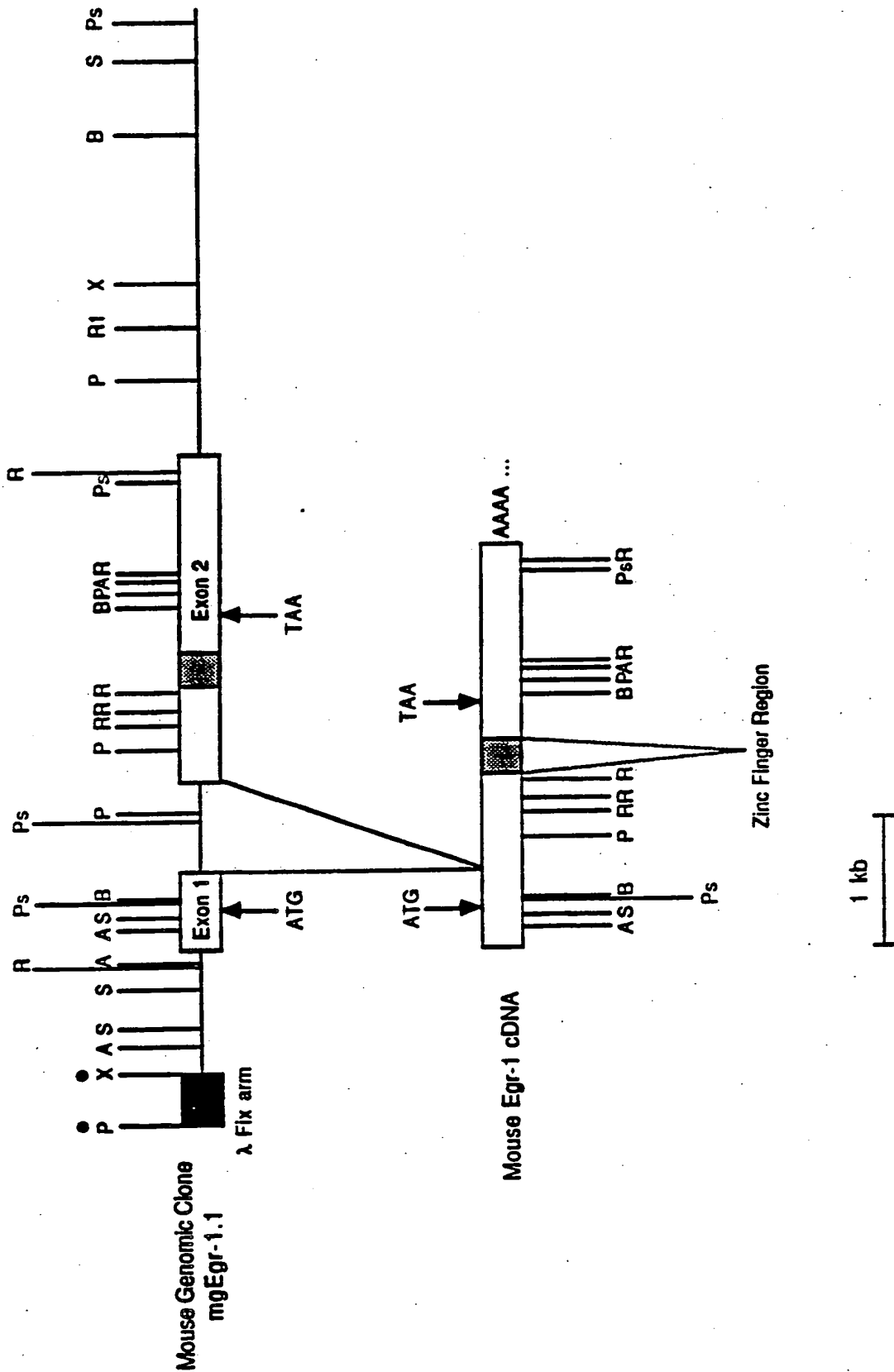


FIGURE 5

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. **PCT/US89/01473**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC CO7H 15/12, C12P 21/00, 19/34; C12N 15/00, 7/00, 1/20; C12Q 1/68; CO7K 13/00														
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Minimum Documentation Searched ⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 20%; border: 1px solid black; padding: 5px;">Classification System</th> <th style="border: 1px solid black; padding: 5px;">Classification Symbols</th> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: middle; width: 20%;">US</td> <td style="border: 1px solid black; padding: 5px;">536/27; 435/68, 91, 172.1, 172.3, 320, 252.3, 6; 530/350, 387</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸</div> <p style="padding: 5px;">CAS database (1967-1989) keywords: finger/protein/motif early growth regulatory/gene/expression/sequence</p>			Classification System	Classification Symbols	US	536/27; 435/68, 91, 172.1, 172.3, 320, 252.3, 6; 530/350, 387								
Classification System	Classification Symbols													
US	536/27; 435/68, 91, 172.1, 172.3, 320, 252.3, 6; 530/350, 387													
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border: 1px solid black; padding: 5px;">Category *</th> <th style="border: 1px solid black; padding: 5px;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%; border: 1px solid black; padding: 5px;">Relevant to Claim No. ¹³</th> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: top; padding: 5px;">X Y</td> <td style="border: 1px solid black; padding: 5px;">Chavrier, P. et al (January 1988) EMBO Journal, Volume 7: 29-35; "A gene encoding a protein with zinc fingers is activated during G₀/G₁ transition in cultured cells. See entire document.</td> <td style="border: 1px solid black; text-align: center; vertical-align: top; padding: 5px;">1-5,8-10 6,7,11,12 14-16</td> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: top; padding: 5px;">X Y</td> <td style="border: 1px solid black; padding: 5px;">Chowdhury, K. et al (March 1988) Cell, Volume 48: 771-778; "A Multigene family encoding several finger structures is present and differentially active in mammalian genomes". See entire document.</td> <td style="border: 1px solid black; text-align: center; vertical-align: top; padding: 5px;">1-5,8-10 6,7,11, 12,14-16</td> </tr> <tr> <td style="border: 1px solid black; text-align: center; vertical-align: top; padding: 5px;">X Y</td> <td style="border: 1px solid black; padding: 5px;">Lau, L. et al (March 1987) PNAS, Volume 84: 1182-1186; "Expression of a set of growth-related immediate early genes in BALB/c 3T3 cells: coordinate regulation with c-fos or c-myc. See entire document</td> <td style="border: 1px solid black; text-align: center; vertical-align: top; padding: 5px;">1-5,7-11 6,12, 14-16</td> </tr> </table>			Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X Y	Chavrier, P. et al (January 1988) EMBO Journal, Volume 7: 29-35; "A gene encoding a protein with zinc fingers is activated during G ₀ /G ₁ transition in cultured cells. See entire document.	1-5,8-10 6,7,11,12 14-16	X Y	Chowdhury, K. et al (March 1988) Cell, Volume 48: 771-778; "A Multigene family encoding several finger structures is present and differentially active in mammalian genomes". See entire document.	1-5,8-10 6,7,11, 12,14-16	X Y	Lau, L. et al (March 1987) PNAS, Volume 84: 1182-1186; "Expression of a set of growth-related immediate early genes in BALB/c 3T3 cells: coordinate regulation with c-fos or c-myc. See entire document	1-5,7-11 6,12, 14-16
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X Y	Chavrier, P. et al (January 1988) EMBO Journal, Volume 7: 29-35; "A gene encoding a protein with zinc fingers is activated during G ₀ /G ₁ transition in cultured cells. See entire document.	1-5,8-10 6,7,11,12 14-16												
X Y	Chowdhury, K. et al (March 1988) Cell, Volume 48: 771-778; "A Multigene family encoding several finger structures is present and differentially active in mammalian genomes". See entire document.	1-5,8-10 6,7,11, 12,14-16												
X Y	Lau, L. et al (March 1987) PNAS, Volume 84: 1182-1186; "Expression of a set of growth-related immediate early genes in BALB/c 3T3 cells: coordinate regulation with c-fos or c-myc. See entire document	1-5,7-11 6,12, 14-16												
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Z" document member of the same patent family</p> </div> </div>														
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border: 1px solid black; padding: 5px;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border: 1px solid black; padding: 5px;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">27 June 1989</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">24 AUG 1989</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">International Searching Authority</td> <td style="border: 1px solid black; padding: 5px;">Signature of Authorized Officer</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">ISA US</td> <td style="border: 1px solid black; padding: 5px; text-align: center;"> Anne Brown </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	27 June 1989	24 AUG 1989	International Searching Authority	Signature of Authorized Officer	ISA US	 Anne Brown				
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report													
27 June 1989	24 AUG 1989													
International Searching Authority	Signature of Authorized Officer													
ISA US	 Anne Brown													

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

P,Y	Pannuti, A. et al (May 1988) Nucleic Acids Res., Volume 16: 4227-4237 "Isolation of CDNAs encoding finger proteins and measurement of the corresponding mRNA levels during myeloid terminal differentiation" See entire document.	1-12, 14-16
P,Y	Almendrol et al (May 1988) Mol Cell Biol, Vol. 8:2140-2148 "Complexity of the Early Genetic Response to Growth Factors in Mouse Fibroblasts". See entire document.	1-12, 14-16

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers _____, because they relate to subject matter ¹² not required to be searched by this Authority, namely:

2. ☐ Claim numbers _____, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out ¹³, specifically:

3. ☐ Claim numbers _____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ²

This International Searching Authority found multiple inventions in this international application as follows:

See attached sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers: 1-12, 14-16

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
☐ No protest accompanied the payment of additional search fees.

ATTACHMENT TO PCT/ISA/210

VI. OBSERVATION WHERE UNITY OF INVENTION IS LACKING

I. Claims 1-12, and 14-16 are drawn to EGR DNA sequence, vector or cell containing it, transformed host, method of using vector or cell and a polypeptide.

II. Claim 13 is drawn to cell-free method of preparing an early growth regulatory protein.

III. Claims 17-19 are drawn to native EGR protein.

IV. Claims 20-23 are drawn to synthetic peptide fragment antigenically related to and containing homology to native EGR protein.

V. Claims 24-29 are drawn to antibodies to EGR, anti-bodies to region EGR, method of using antibody.

VI. Claim 30 is drawn to method of detecting mRNA.

VII. Claim 31 is drawn to method of detecting DNA.

VIII. Claim 32 is drawn to method of diagnosis.

The claims do not embrace one single general inventive concept as defined in Rule 13.

Groups I, III, IV and V contain claims directed to distinct chemical entities. These are a gene and a protein coded for by that gene, a native EGR protein, a synthetic peptide fragment, antibodies which bind to EGR proteins. Groups II, VI, VII and VIII are directed to alternative uses for the nucleotide defined in Group I.

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